Title: Air-conditioning

INTRODUCTION

This invention relates to air-conditioning particularly for use with motor vehicles.

BACKGROUND OF THE INVENTION

There are many situations with motor vehicles where there is a need for air-conditioning. In motor sport, safety requirements dictate that drivers have to wear fire resistant clothing and crash helmets. The design of the motor vehicles and their operating conditions is such that it is not unusual for drivers to have to operate the vehicles for lengthy periods at temperatures in excess of 50°C. Driving a car at high speed at these temperatures is a physically demanding exercise and there have been a number of suggested means of cooling the driver. One such suggestion is to provide a source of cool air that is fed into the helmet of the driver or into the driver's safety suit to cool down the driver when the operating temperatures become excessive.

Conventional air-conditioning units for vehicles incorporate a compressor that is usually driven from the engine of the vehicle. The compressor is bulky and uses a considerable amount of power from the vehicle's engine. In high performance racing cars there is neither the space nor the excess power to allow the engine to be used to power an air-conditioning unit.

There are other situations both with regard to motor vehicles and aircraft where there is a need for a small, compact and low powered air-conditioning unit that is not dependant on the engine of the vehicle to operate. Such situations include aircraft, truck sleeper cabins, leisure vehicles such as caravans and campervans. There is also a range of military vehicles including tanks in which

there is a need for air conditioning units that operate even when the vehicle's engine is not running..

It is these issues that have brought about the present invention.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there is provided a reverse cycle air-conditioning unit comprising an evaporator, a condenser and a compressor coupled in a closed circuit to cycle a refrigerant, the compressor being powered by a low voltage DC electric motor and the circuit including a valve to reverse the direction of flow of the refrigerant.

Preferably, the evaporator and condenser are positioned adjacent a fan driven by a low voltage DC electric motor. The voltage is preferably 12 or 24 volts.

Preferably the valve comprises a four way valve operable by a solenoid to reverse the direction of flow of the refrigerant.

In accordance with a further aspect of the present invention there is provided an air supply system for the driver of a vehicle, the system comprising an air-conditioning unit including an evaporator, a condenser and a compressor coupled in a closed circuit to cycle a refrigerant, the compressor being powered by a 12 volt DC electric motor, and a fan driven by a 12 volt electric motor being positioned adjacent the evaporator to draw a source of fresh air through the evaporator and into an air conduit arranged to be coupled directly to the driver.

Preferably the driver is wearing a driving suit and/or helmet and the air conduit is coupled to the suit and/or helmet.

The air conduit preferably incorporates a filter to control the rate of flow and filter out dangerous gases such as carbon monoxide. Preferably the flow rate is controlled to be approximately 2 litres per second.

The system may be coupled to a data logger that monitors the relative humidity and temperatures in the vehicle.

DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1A is a side view of an air-conditioning circuit for an air supply system,

Figure 1B is a side view of the air supply ducting of the system with the plumbing removed,

Figure 2 is a plan view of the circuit shown in Fig. 1A,

Figures 3A, 3B and 3C are side elevational views of components of a compressor forming part of the system,

Figure 4 is a perspective view of an electric motor used to drive the compressor of the system;

Figure 5 is a perspective view of the outer casing of an air conditioning unit in accordance with a second embodiment,

Figure 6 is a side view of the unit with most of the casing removed,

Figure 7 is the opposite side view of the unit with most of the casing removed,

Figure 8 is a side view of a condenser or evaporator and fan assembly,

Figures 9A, 9B and 9C are elevation and plan views of an evaporator,

Figures 10A, 10B and 10C are elevation and plan views of a condenser,

Figure 11 is a circuit diagram illustrating a reverse cycle unit, and

Figures 12A and 12B are views of a four way reverse valve in two operating modes.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The air-conditioning system 10 illustrated in Figures 1 to 4 of the accompanying drawings is designed to be positioned in the floor of a V8 Super Car, that is a V8 saloon car that has been modified for track racing. The air-conditioning unit is specifically designed to be small so that the whole unit fits on a tray 11 that measures 380mm by 290mm with the unit extending upwardly to a height of about 250mm.

As shown in Figures 1 and 2 the air-conditioning system 10 comprises an evaporator 20 and a condenser 40 partitioned at opposite ends of the tray 11. A compressor 30 causes on suitable refrigerant to exit the high pressure end 72 of the compressor and pass to the upper end 43 of the condenser 40. The lower end 41 of the condenser 40 is coupled to the evaporator 20 via a line containing in series a drier 42, filter 76 and a TX valve 31. The outlet 77 of the evaporator is coupled to the low pressure side 73 of the compressor 30.

The air-conditioning unit 10 defines a closed circuit that cycles a suitable refrigerant which on compression in the compressor 30 and cooled to liquid in the condenser 40, expands in the evaporator 20 to draw heat from the atmosphere to provide an output of cool air that is drawn from the rear of the evaporator 20 by a blower and blower duct 21. A source of fresh air is applied to the evaporator 20 and the rear of the evaporator 20 is enclosed by a shroud 25 that is in turn coupled to an electric motor (not shown) that drives the blower 22. The rear of the blower duct 21 includes a granulated carbon

filter (not shown) and provide an output with a source of cool air which can then be fed to the helmet or driving suit of the driver of the V8 Super Car. The blower 22, compressor 30 and condenser fan (not shown) are all driven by 12 volt DC electric motors and the power for these motors can come from the electrical power of the vehicle that is produced by the alternator that is in turn driven by the engine.

In order to be run by a 12 volt DC motor, the compressor must be small and very efficient. The compressor 30 as shown in detail in Figures 3A, 3B and 3C and comprises a single reciprocating piston 60 that is driven by a crankshaft 61. The crankshaft 61 is coupled via a flexible coupling to an electric motor 70 shown in Figure 4. The piston head 62 is secured to the piston rod 63 by a gudgeon pin 64 and the head 62 carries suitable piston ring 65. The piston has a 0.9 inch diameter and the length of the piston is about 65mm. The crankshaft 61 is located in a crank case 66 by a bearing 67 and the piston 60 reciprocates in a stainless steel cylinder 68 that is covered by a head 69. The head 69 includes two stainless steel reed valves (not shown) each mounted on an inlet (not shown) and outlet port 72. When the reed valves are shut the compressor sucks in refrigerant from the TX valve and when the reed valves are open the compressed refrigerant is discharged to the condenser 40.

It is understood that the stroke and bore of the piston may vary. The compressor is very small but operates at high pressures up to 150psi. It is a totally sealed unit that runs at between 1500 and 4000rpm. The crankcase 66 of the compressor 30 is pressured by refrigerant at low pressure via a branch line 79 from the TX valve 31 to reduce the pressure difference an opposite sides of the piston head 62.

The electric motor 70 that drives the crankshaft 61 of the compressor 30 is shown in Figure 4 and the motor that drives the fan for the evaporator 20 and blower 22 are rare earth motors that can have speed varying controllers mounted thereon. Alternatively the rare earth motors can be replaced by computer fan type motors that draw very low currents and have a running life of over 60,000 hours.

The air-conditioning unit 10 described above is designed to drop the air temperature by about 15°C and is adjusted to operate in this range. The use of 12 volt DC motors operate at approximately 9amps which means that the air-conditioning unit 10 consumes about 108W of power. It is envisaged to reduce the current usage down to 4.5amps which would halve the power consumption.

Although in the preferred embodiment the air-conditioning unit 10 is mounted so that the evaporator 20 and condenser 40 are mounted on opposite ends of the plate 11 with the electric motor 70 and compressor 30 supported therebetween, it is understood that the componentry could be spread around a vehicle or aircraft and coupled by suitable flexible hose. In this way the unit could be designed to take up a minimum amount of space. The high pressure line from the condenser 40 to the TX valve 31 is via a sight glass 75 and combined filter and drier 76. The filter adjacent the blower 22 can be used to restrict the airflow down to the desired rate of 2L per second.

It is further understood that the air-conditioning unit can be coupled to a data logger, that is a system that monitors the data in the V8 touring car to measure temperature, humidity and other related parameters.

It is envisaged that the unit would be directly coupled to the helmet and/or driving suit of a V8 touring

car. The use of filters to filter out dangerous gases such as carbon monoxide leaves the driver fresh and clear headed to ensure optimum driving performance. Whilst the air supply system has been designed for use with V8 super cars it is understood that the system could be implemented in many vehicles where the driver requires a source of cool filtered air. Such vehicles include racing cars, mining vehicles and military vehicles.

In a second embodiment shown in Figures 5 to 12, an air-conditioning unit 100 has been modified specifically for use as a means of cooling living spaces such as the sleeping cab of a truck or caravan or campervan. The unit 100 is designed to be compact and portable and to run efficiently of a 12 or 24 volt battery so that air-conditioning can be provided in a truck, cab, campervan or caravan without the need to operate the engine of the vehicle.

In this embodiment the componentry, namely the condenser 140, evaporator 120 and compressor 130 are positioned within a rectangular box 110 (Figure 5) that includes a base tray 111, side walls 112 and 113, end walls 114 and 115 and top 116. Suitable grilles are provided on the end walls and one side wall has an air inlet grille 119. The tray 111 supports a very small and efficient compressor 130, the high pressure side of which is coupled to the inlet 143 at the top of the condenser. The output 141 of the condenser is fed to the input of the evaporator via a capillary valve 131 that essentially comprises a four metre length of copper capillary tubing of narrow diameter wound into a coil. The length and diameter of the capillary tube determines the rate of flow and controls the delivery of liquid refrigerant to the evaporator. The output of the evaporator is connected to the low pressure side of the compressor to complete the refrigeration cycle. Electric motors drive fans located

on the interior side of both the condenser 140 and evaporator 120. The electric motors are preferably 12 volt dc computer fan motors that use very low levels of current and have a long running life.

In this embodiment the compressor 130 is an off the shelf refrigeration compressor sold by the German company Danfoss under Model BD50F. It operates on refrigerant R134A between 12 and 24 volts. The compressor is oil cooled and lubricated and weighs approximately 3.4 kg. The dimensions of the compressor are less than 140mm in height, about 200mm in width and about 130mm in depth. The electric motor is a variable speed motor and the compressor has a 2 cm^3 displacement, a maximum refrigerant charge of 300g and a free gas volume of 870 cm^3. The compressor has a battery protection setting that can be adjusted through use of variable resistors to ensure that when a voltage drops to a certain level the compressor cuts out. Thus in a twelve volt situation the voltage cuts out at 10.4 volts and cuts back in at 11.7. In a 24 volt situation the voltage drops out at 22.8 volts and cuts back in at 24.2. This cutout ensures that over use of the air-conditioning system does not flatten the battery of an associated vehicle.

In testing of the air-conditioning unit it has been discovered that drawing air through the evaporator is a more efficient means of operating the unit than blowing air through the evaporator. It has also been discovered that a 35mm air gap between the coil 121 of the evaporator and the fan blades 122 increases the efficiency. Air flow is preferably set at about 40 litres per second. The fan 122 has a blade diameter of about 120mm and the arrangement which is applicable to both the evaporator and condenser is shown in Figure 8.

Other features that can be incorporated into the air-conditioning unit of the embodiment shown in Figures 5 to 12 is the capacity for reverse cycle flow whereby by changing the direction of flow of the refrigerant the role of the condenser 140 and the evaporator 120 are reversed so that the evaporator becomes hot so that by drawing or blowing air across the hot coil warms the area in which the unit is housed. A circuit of the reverse cycle arrangement is shown in Figure 11. To change the direction of flow of the refrigerant a four way reverse valve 150 shown in Figures 12a and 12b is positioned between the compressor 130 and the evaporator 120. The valve has an inlet or discharge port 151 that communicates with three outlet ports 152, 153, 154. A solenoid 155 can be activated to alternate flow from one outlet to another. In the open position shown in Figure 12a of the right hand outlets 153, 154 are interconnected and disconnected from the discharge 151. In the closed position shown in Figure 12b the left hand outlets 152, 153 are interconnected and disconnected from the inlet 151. The valve ensures that the open position flow is from the compressor to the condenser (the cooling mode) and in the open position flow in to the evaporator (heating mode). The reverse cycle operation also requires the need to install in parallel TX valves or capillary valves 156, 157 as shown in Figure 11.

The device may also include a thermostatically controlled switch that can operate on a timer to operate and control the valves in a required sequence and to cause periodic defrosting of the coil to rid the coil of condensation to prevent icing up of the coil. The use of an electronic timer and temperature control can be used to provide a means of climate control so that the device operates automatically between an air-conditioning or cooling unit and a heating unit.

The condenser 140 of the second embodiment is illustrated in detail in Figures 10a, 10b and 10c and comprises a thin (5mm) 45mm wide plate like aluminium extrusion including elongate 4mm parallel tubes is wound into a single serpentine shape 141 and bent across a former to produce eleven horizontal passes. Cooling fins 142 are attached to the extrusion in a coarse vertical array to improve air flow. The input 143 to the condenser 140 is positioned as shown in Figure 10B at the top of the unit with the flow through the serpentine arrangement reversing ten times until the refrigerant leaves the outlet 145 of the condenser at the base. The condenser 140 is mounted vertically at one end of the unit.

The evaporator 120 includes a serpentine coil 121 of similar design and this is shown in Figures 9a, 9b and 9c. The inlet 124 and outlet 125 of the evaporator are both positioned on the top of the unit and the single coil is made of a thin (5mm) 85mm plate of aluminium wound into a single serpentine shape and bent around a former to produce ten vertical passes. A series of cooling fins 146 extend horizontally joining the passes and the unit is mounted vertically as shown in Figure 9b. Suitable 8mm connectors can be incorporated into both the condenser and the evaporator to ensure simple connection to the compressor.